# A CONTRIBUTION TO THE STUDY OF THE INTER-GLACIAL GORGE PROBLEM.[1]

*Topography of the Finger Lake region.*—The topography of the Finger Lake region is too well known to American geologists to require any detailed description here. The rocks, which are almost wholly Devonian, consist of great deposits of shale and sandstone, with a few thin beds of limestone. These rocks have never been greatly disturbed and lie nearly horizontal, with a slight southward dip. In the Cayuga Lake district there is a series of gentle folds which cross the lake valley in the east-west direction. A glance at the even sky-line presented by the hill-tops shows that the region is a great plateau. This plateau has been so deeply dissected that it resembles a mountainous country, with the hills often rising several hundred feet above the valley bottoms. About fifteen miles south of the heads of the lakes is a dissected divide that Professor Tarr[2] has characterized as being "high and diverse in topography." From the divide the plateau slopes northward and merges into a drift-filled region at the northern ends of the lakes. Here, doubtless, there was an escarpment in preglacial times, but it is now nearly obscured by drift.

*Cayuga Lake valley.*—From the divide at Spencer Summit the valley of Lake Cayuga extends northward a distance of nearly fifty miles, when it is lost beneath the drift. Professor Tarr[3] has called the divide at Spencer Summit a divide of "destructional origin." He considers the depth of the drift here to be slight; and from the steepness of the walls he infers that the divide must have been higher in preglacial times, "having been lowered

[1]This paper was originally written as a thesis for the master's degree at Cornell University. Since the preparation of the original manuscript enough new information has been secured to warrant a slight revision, and therefore some changes have been made. The writer is indebted to Professor R. S. Tarr for many valuable suggestions concerning the field investigations and the preparation of the original paper.

[2]R. S. TARR, *Bulletin No. 5*, Geological Society of America, p. 340.

[3]*Ibid.*, p. 341.

by glacial erosion." There is also good reason for believing that the divide has been lowered by stream erosion. The ice in its advance would close the outlet of the lake valley, causing a lake to be formed between the ice front and the divide. The drainage of this lake across the divide would continue until the ice had advanced to the divide. In receding the ice would again cause the formation of a lake in the valley, which would exist from the time the divide was uncovered until the ice retreated far enough to uncover a lower outlet. The drainage across the divide would naturally tend to lower it. The amount of erosion would vary with the length of the time. The presence in Cayuga Valley of the well-developed terminal moraine of the Wisconsin glacial epoch points to the existence of an ice-dam in the valley for a long time. This fact points to the probability of the divide having been considerably lowered by stream erosion. The effect of the drainage across the divide would be influenced by the relative altitude of the northward- and southward-flowing streams. If the southward-flowing streams had cut considerably below the level of those flowing northward, the water would fall into the deeper valleys, and the divide might be destroyed in a very short time by the recession of this waterfall. If, as seems more probable, the northward-flowing streams had reached the lower level, the removal of the divide would be much slower. On this point Professor T. L. Watson has said:

> It can hardly be doubted that the Laurentian tributaries were the stronger streams, therefore encroaching upon the territory of the other system, and thereby causing the southward migration of the divide.[1]

We should also bear in mind that there is a possibility of a differential uplift having rejuvenated the Laurentian streams just before the glacial period. Mr. M. L. Fuller[2] failed to find evidence of this uplift in the area covered by the "Elkland-Tioga Folio":

> It has been frequently urged among geologists that the advent of the earliest Pleistocene ice-sheet was preceded by a general uplift of the northern half of the continent, affecting the surface throughout the northern por-

[1] "Some Higher Levels in the Post Glacial Development of the Finger Lakes," *Report*, N. Y. State Museum, Vol. I (1897), p. R. 68.

[2] M. L. FULLER, "Elkland-Tioga Folio," U. S. Geological Survey, p. 7.

tion of the United States. In western Pennsylvania, however, the presence of Pleistocene river gravels on rock terraces several hundred feet above the bottom of the present gorge of the upper Allegheny River indicates that the last stage of the active erosion did not begin there until after the first ice invasion, though the uplift and the inauguration of the erosion in the lower reaches of the river may have been somewhat earlier. The uplift recorded by the rock terraces immediately adjacent to the Susquehanna in the eastern portion of the state is of questionable date, but would appear to be of late Tertiary or early Pleistocene age.

In the Elkland-Tioga region there appears to be a slight notching in the bottom of the old valley of Pine Creek and some of its tributaries, but it is believed that this was not produced until after the southward deflection of the lower portion of the creek through the gorge south of Ansonia. This diversion, as will be described more fully in the discussion of the earliest glacial stage, was probably due in great measure to the accumulation and overflow of waters ponded in front of the advancing ice-sheet, and the consequent reduction of the divides and the cutting of a new channel in which the stream persisted even after the ice had disappeared. The notching of the bottom of Pine Valley and its branches was a result of the diversion through the new and lower channel, and affords no evidence of uplift.

The Elkland-Tioga region is not far from the Finger Lake region. It is, however, on the south side of the divide, and includes some of the streams which are tributary to the headwaters of the Susquehanna River. If rejuvenation had effected the Laurentian drainage, this would tend to increase rather than diminish the advantage of the northward-flowing streams over those flowing southward.

The hills, which rise steeply at the southern end of the lake valley, become lower and more gently sloping as you pass northward. The valley also widens rapidly toward the north. While a mature stream valley ought to become wider and the walls more rounded toward the mouth of the stream, the change here is so rapid as to suggest that there must be some other explanation to account for a part of the difference. One cause which has probably contributed to this end is the northward differential depression which occurred at the close of the glacial period. If this depression amounted to no more that two feet per mile, it would have made a difference of one hundred feet in the relative height of the land at the ends of Cayuga Valley. It has been suggested that the difference in the topography at the

two ends of Cayuga Valley is due to a difference in rock texture.[1] The southern part of Cayuga Valley is cut in the hard, durable Portage sandstone, while farther north are the soft Hamilton shales which break down much more easily when exposed to the agents of weathering. Another point of considerable, though undetermined, importance in this connection is the intense glaciation to which the northern end of the lake valley has been subjected. As suggested by Dr. G. K. Gilbert,[2] the belt in which the northern end of the lake lies has been much more intensely scoured by the ice than the belt south of the lake. The width of the lake varies from about a mile near its southern end to about three miles near Aurora. The surface is 378 feet A. T., and the greatest depth is 432 feet. For considerably more than half its length the bottom of Cayuga Lake is below sea level. The drainage of Cayuga Valley is northward into Lake Ontario.

*Direction of preglacial drainage.*—While some of the earlier writers believed that the preglacial river which occupied Cayuga Valley flowed southward, all the later students are agreed that it drained northward into the Ontario basin. The hypothesis of a northward preglacial drainage is based on the following lines of evidence: the general northward slope of the land; the wider and more mature aspect of the valley as one passes northward from the divide; the increasing number of tributaries near the divide; and the fact that the bottoms of the mature tributaries become lower from the divide northward. While all these lines of evidence have been affected by the various changes accompanying glaciation, it has not been sufficient to destroy their value as evidence in this connection. Since there are no facts opposed to the theory of a preglacial drainage toward the north, we may regard the hypothesis as established.

*Postglacial gorges.*— With few exceptions, all the tributary streams which occupy mature preglacial valleys enter the main valley through narrow, rock-walled, postglacial gorges contain-

[1] *New York Geological Survey of the Fourth District* (1843), p. 225; *Monograph XLI*, U. S. Geological Survey, p. 79.

[2] Paper read before the Geological Society of America, December, 1902.

ing many rapids and waterfalls. The length of these postglacial gorges is usually less than three miles; and the amount of fall varies from about 100 feet to over 500 feet per mile. The descent is usually accomplished by means of a series of cascades, though

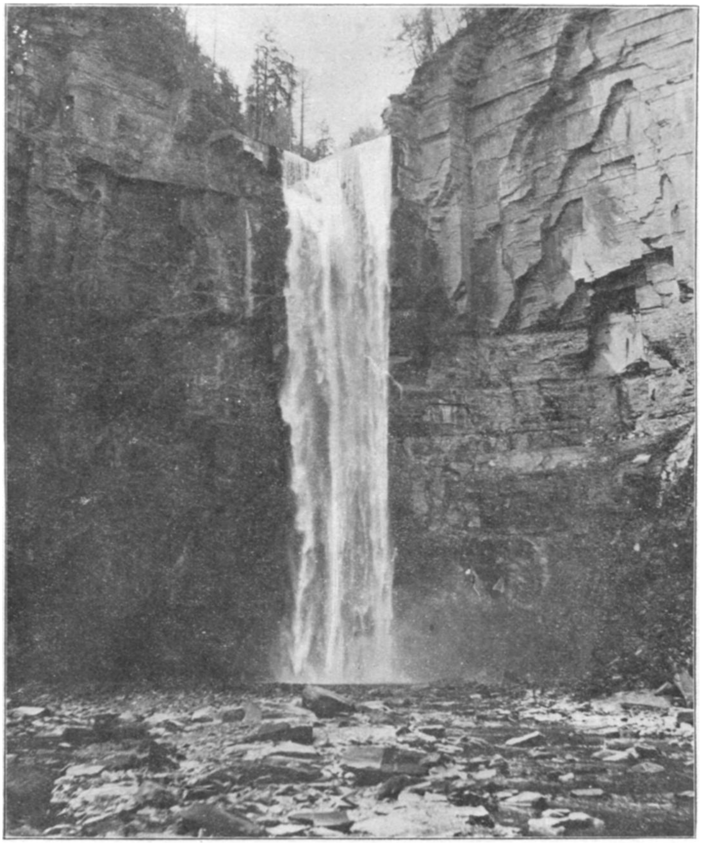


FIG. 1.—Taghanic Falls.

in a few cases there are cataracts of considerable height. Taghanic[1] Falls, the highest, measures 200 feet. Many of these falls have developed on account of an alteration of hard sandy layers with layers of soft, easily eroded shale. A few cataracts

[1] This spelling is in accordance with that on the Genoa atlas sheet of U. S. Geological Survey.

also occur over the Tully limestone, which caps the soft Hamilton shales. In general, the amount of fall in the postglacial gorges diminishes toward the north, although there are some exceptions to this rule.

The principal cause for this gorge condition, in the lower part of the tributary valleys, is the fact that the streams have been turned from their old channels and forced to cut new ones. Another cause which has contributed to the same end is the widening and deepening of the main valley by glacial erosion. In some cases the streams have possibly been turned aside by a moraine dam, but the most common obstructions are the deltas deposited in the ice-dammed lakes[1] which formed in front of the continental glacier. These lakes fell to successively lower levels when lower outlets were uncovered, and the streams continued to flow along the course occupied when the lakes fell. The new channels are mostly south of the old course, and Professor Tarr[2] has attributed this to the effect of the prevailing north winds on the waters of the extinct lake. Coy Glen, being exposed to the south winds and protected from the north winds, lies north of its old channel.

*Interglacial gorges.*— In every case where the streams have been turned aside in the manner just described there is a lower course in the same broad valley, which is itself a gorge. Professor Tarr has already called attention to these gorges in his *Physical Geography of New York.*[3]

*Interglacial (?) gorges.*—In central New York there are numerous gorges which are broader than the postglacial valleys and partially obscured by glacial till, showing that they were formed either during preglacial or interglacial times. This class of valley is especially well illustrated in Six Mile Creek, where its relation to the broad, mature preglacial valley is well shown. In one case, near Taghanic Valley, lake beds containing fresh-water fossils have been found beneath the till.

One naturally thinks of these gorges as being interglacial in

[1] H. L. FAIRCHILD, *Bulletin VI*, Geological Society of America (1895), pp. 353–74; T. L. WATSON, *Report*, New York State Museum (1897), pp. 55–117.

[2] *Physical Geography*, N. Y., p. 177.

[3] Pp. 178, 179.

origin, and this explanation seems, at present, the most probable; but all that can now be said with certainty is that they antedate the last advance of the ice. The question of these gorges has a very important bearing upon the whole subject of the drainage history of central and western New York. Were the gorges due to interglacial conditions or to an uplift of preglacial times? Leverett refers to similar gorges in his monograph[1] on *The Glacial Formations and Drainage Features of the Erie and Ohio Basins.*

The valleys of this hilly country present marked differences in topography. In some valleys the slopes from top to bottom have a mature aspect, while in others the upper part of the slope is mature, but the lower part is gorge-like and youthful in appearance. The phenomena suggests at once that some valleys have remained below the level of stream-cutting, while others have been undergoing a marked trenching. In these which have been deepened, the old valley bottoms are traceable along the brow of the rock gorges or canyon valleys, for the old valleys are generally broader than the new ones. In some cases, however, the new valleys occupy the whole width of the bottoms of the old ones, and there is only the change in the angle of the slope of the valley bluff to mark the depth of the old valley. There is, in some valleys a series of complex terraces or rock shelves, of which one set or system stands at the brow or border of the canyon valley, and the others at higher altitudes. There are also, in some cases, rock shelves inside the trenches of the canyon valleys. The set of trenches standing at the brow of the canyon valley is, however, a far more persistent feature than any of the others, and it is this set which receives chief attention in the ensuing discussion of drainage systems. It seems to mark a true gradation plain, formed when the stream was in condition between degrading and aggrading its bed.

All the preglacial tributaries of Cayuga Lake Valley which have been examined have gorges cut in their bottoms, and these gorges are wider, and in many cases deeper, than the postglacial gorges. The approximate width of the drift-filled gorges can usually be ascertained without much difficulty. On account of the drift-filling, the depth is not readily determined; however, Evans, who studied Taghanic carefully, mapped the old valley bottom as continuous above the level of Lake Cayuga.[2]

*Ten Mile Creek.*—Ten Mile Creek, despite its name, is only about six miles in length. It rises near the village of Danby and flows a little west of north, entering the Inlet about two miles

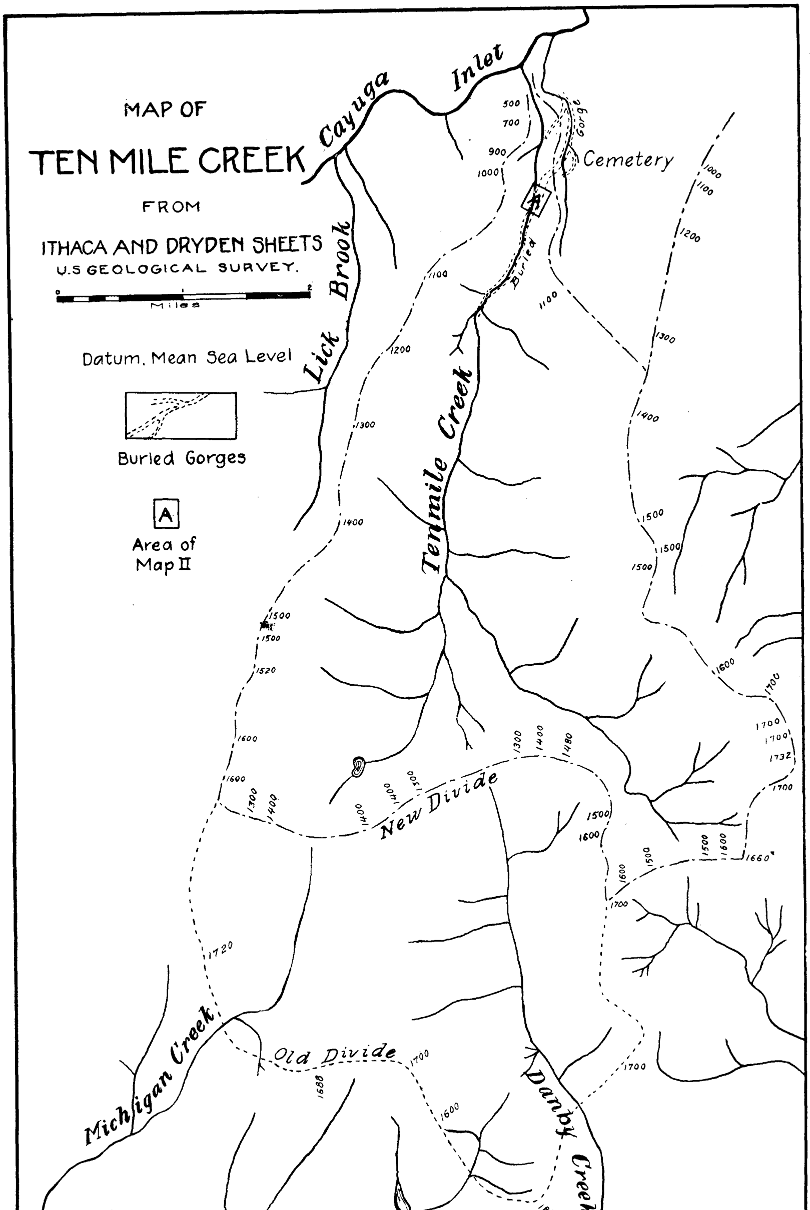
[1] *Monograph XLI*, U. S. Geological Survey, p. 80.

[2] R. M. Evans, Thesis on Taghanic (1897), Map. II.

south of Ithaca. The stream occupies a broad, mature valley with gently sloping sides. This valley divides at Danby, the branches becoming narrower and the walls steeper for some distance beyond the village. While Ten Mile Creek now rises at Danby, there is evidence that the preglacial divide was farther south. Danby Creek, which rises near the east branch of Ten Mile Creek, flows southward through a valley which gradually narrows for a distance of three miles and then widens again. Michigan Creek, which heads near the west branch, flows through a similar valley; but in this case the narrowest part of the valley is only about two miles from the source of the stream. The narrowing of these mature valleys cannot be explained on the ground of rock texture, for the rocks here are of uniform character. The narrowing may be explained by supposing that the narrowest part represents the divide between these streams at the time the broad valleys were being formed. The divide hypothesis is strengthened by the fact that the highest hills are on either side of the narrowest parts of the valleys; and by the additional fact that the present divides are clearly of constructional origin, being composed of low drift ridges. The drift ridges are within the limits of the region covered by the last ice-sheet; and the present location of the divides was determined by the material deposited at the ice-front.[1]

About a mile from the Inlet, Ten Mile Creek enters a narrow postglacial gorge; and in less than a mile it falls, by a series of rapids and cascades, through a vertical distance of about 420 feet. The highest falls are the two cascades near the edge of the inlet, which together measure 190 feet. Running nearly parallel to this gorge is a drift-filled gorge, which is much broader and deeper than the postglacial gorge, as shown by sections 1 and 2. The buried gorge is now occupied by a small stream which has removed the drift down to 520 feet A. T., but has not reached the rock bottom. The width of this gorge is 250 yards; its depth is not known, but the north wall rides 156 feet above the drift which forms the bed of the present stream. The lower end of this stream is through a small postglacial gorge, cut in the north

[1] For location of the divides, see Map I.




(This map should be inserted in Vol. XII, No. 2, February-March, 1904, of the JOURNAL OF GEOLOGY, to face page 140.)

wall of the filled gorge. There is a rock terrace[1] on the south side of the buried gorge at 620 feet A. T., which probably represents a former level of the stream, for there is a tributary gorge on the north side near the cemetery which enters the main gorge at about the level of this terrace. The tributary shows as a gap in the wall of the main gorge, just below the cemetery and it is crossed by a small stream just above the cemetery. A short dis-

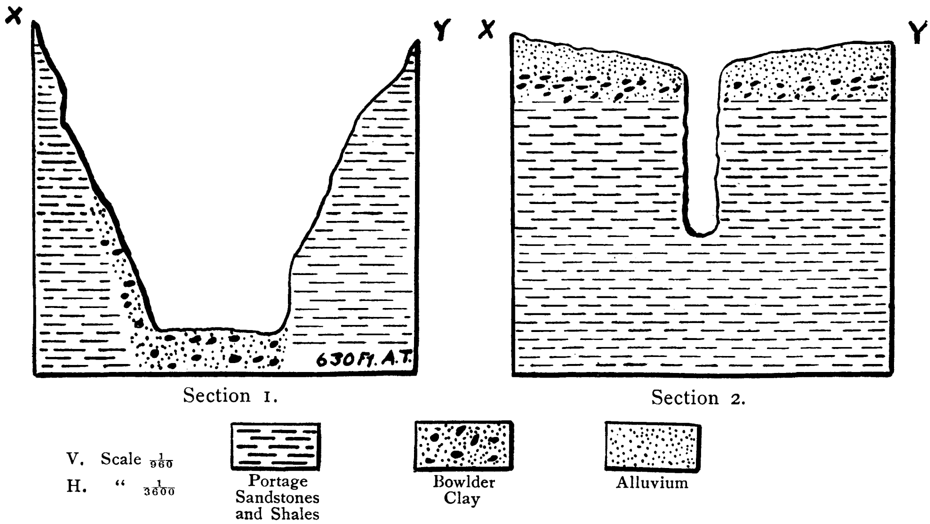



FIG. 2.

tance from the inlet the present stream crosses a small buried gorge, which must have been another tributary, for the rock is practically continuous at 720 feet A. T. between the old gorge and the postglacial gorge.

If we look upstream for the continuation of the large buried gorge, we find that it appears just above the delta which was built by the stream in Glacial Lake Ithaca.[2] Above this delta the gorge can be traced nearly a mile to where it is finally obscured by the drift. In that distance the stream has cut two small postglacial gorges around drift obstructions which block

[1] The writer has begun a study of these rock-shelves which he hopes will lead to an explanation of the direction of flow, and at the same time elucidate some other points. The photograph taken in Six Mile Creek shows two terraces.

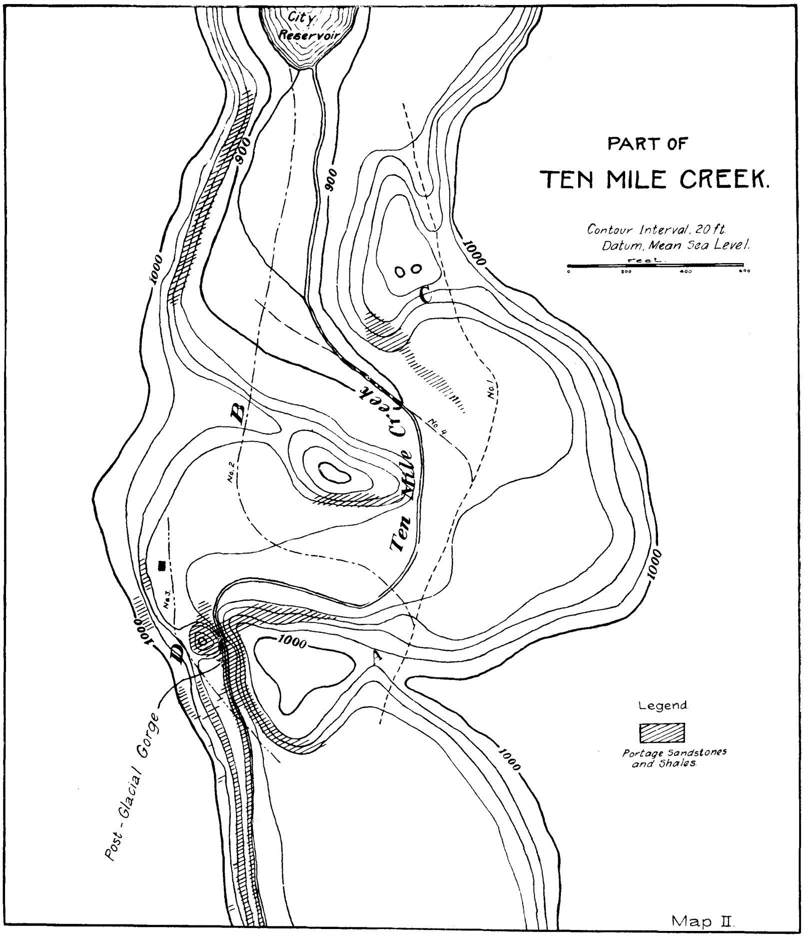
[2] T. L. WATSON, *Report*, New York State Museum (1897), pp. r55–r117.

the main gorge. One of these postglacial gorges is shown on Map II.

Map II comprises an area 1,000 yards long, and from 250 to 600 yards wide. The lowest part of the map is at the city reservoir, 880 feet A. T. The contours were mapped on either side of the stream up to 1,000 feet A. T. Above the 1,000-feet contour the surface rises very gently to the divides between Ten Mile Creek and the neighboring streams. There are three ridges on the map which extend nearly east and west, and rise to a height of 100 feet above the stream. Each ridge is composed partly of drift and partly of rock covered with drift.

*Channels of Map II.*—The stream enters the map through a broad drift floored channel, and, after crossing the rock in the southern ridge through a narrow postglacial gorge, it enters another drift-floored channel, through which it flows to the city reservoir. Below the reservoir the stream flows through the narrow postglacial gorge described earlier in this paper. In addition to the channels now occupied by the stream, there are four other channels within the area of Map II. Two of these channels pass beneath the southern ridge, one east of the present stream (see map, *A*), and one west of the present stream, and just south of the house (see map, *D*). There is a channel beneath the middle ridge west of the rock outcrop (see map, *B*), and one beneath the northern ridge, east of the rock outcrop (see map, *C*).

*Evidence of the existence of channels.*—The general evidence of the existence of these channels is of two kinds: (1) the trend of the rock outcrops; (2) the existence of well-defined indentations on the upstream side of each of the ridges. These indentations were produced by the stream swinging against the soft drift ridges. The drift was not entirely removed from the channel, because the rock in the ridges prevented the formation of a broad meander within these channels. In the case of the channel (*D*), west of the postglacial gorge, the drift ridge has been so badly eroded that the rock-walls show above it, and near the southern end of this channel the wall has been exposed down to the bottom of the channel (Plate V). The hypothesis of a




(This map should be inserted in Vol. XII, No. 2, February-March, 1904, of the JOURNAL OF GEOLOGY, to face page 142.)

channel ($A$), east of the postglacial gorge, is strengthened by the fact that the channel west of the postglacial gorge is too narrow and too shallow to be the continuation of the broad channel south of the ridge. The existence of a channel ($B$) beneath

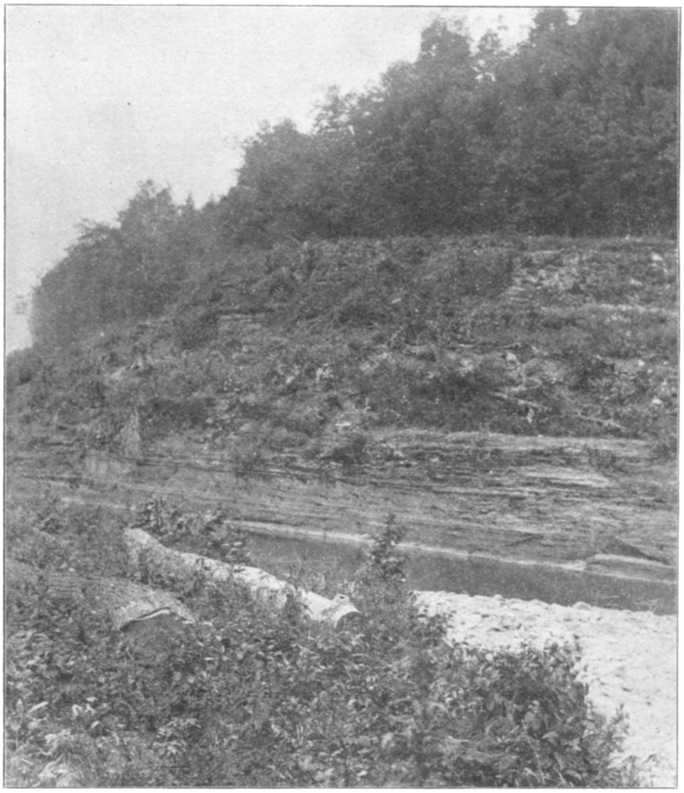


FIG. 3.— Terraces in the drift-filled gorge of Six Mile Creek.

the middle ridge is very apparent in the field; and is fairly well shown by Plate VI. A boring made on the top of the ridge to a depth of ten feet did not strike rock, although the bottom of this hole is more than twenty feet below the highest rock in this ridge. The channel between the middle and north ridges seems rather narrow to be the continuation of the broad channel on the east side of the map, and the well-defined indentation (see Plate

VI and Map II, *C*) on the south side of the north ridge, points strongly toward the existence of a channel beneath the ridge.

*Nature and size of channels.*—The fact that the rock rises perpendicularly above each of these channels indicates that they are gorges, and the rock in each of the ridges forms a rock island. The postglacial gorge is 25 yards wide, 50 yards long, and 90 feet deep. The gorge south of the southern ridge is over 250 yards wide and 100 feet deep. The drift has been removed down to 910 feet A. T. without exposing the rock bottom. The gorge (*D*) just south of the house is 35 yards wide and 90 feet deep. It has its bottom at 910 feet A. T. This is at the same time level as the bottom of the postglacial gorge. The gorge running east from the house is 125 yards wide and 110 feet deep. Its bottom, as indicated by borings near the house and between the rock in the two ridges, is below 890 feet A. T. The gorge just south of the reservoir is more than 175 yards wide and it has been cut to 880 feet A. T. without encountering rock. This would give it a depth of 120 feet. The gorge between the middle and northern rock islands, is 125 yards wide and has a drift bottom 900 feet A. T. The outcrop along the stream at the east end of this gorge, is an extension of the rock in the northern ridge and it was probably originally at the same height, having been lowered by the swinging of the stream against it. It now stands 905 feet A. T.

The arrangement of the sections of gorges into a series of continuous gorges depends upon size, depth, and position. Gorge No. 1[1] passes beneath the southern ridge, east of the middle ridge, and east of the rock in the northern ridge. From the slope of the rock-floor of the broad valley, as indicated by well records and rock outcrops, this channel must lie approximately in the axis of the broad valley of Ten Mile Creek, already described. Gorge No. 2 passes beneath the southern ridge, westward past the house, beneath the middle ridge, and west of the northern ridge. That this gorge could not pass between the middle and northern ridges is shown by the fact that its bottom

[1] The numbering is for convenience only, and does not indicate the supposed chronological order of formation.

is lower than the low rock outcrop which extends along the eastern edge of this channel. We still have left Gorge No. 3 and Gorge No. 4. These gorges may possibly belong together, though that is by no means certain. By taking the low ridge of rock east of the stream as one edge of Gorge No. 4, we can reduce its width to 75 yards, but it is still nearly three times as

FIG. 4.—A view in the drift-filled gorge of Ten Mile Creek.

wide as Gorge No. 3, and it is also more than 10 feet deeper. If, however, we assume that there was a fall somewhere between the two gorges, it would account for the difference in depth; but this assumption does not explain the difference in width.

*Downstream extension of these gorges.*—All these gorges must have entered the inlet through the broad gorge below the reservoir, which lies north of the postglacial gorge, for the rock-wall of the Inlet Valley is continuous for two miles on either side of the drift-filled gorge, except where there are postglacial trenches. It is possible that there is a local divergence of the small

drift-filled gorge. The stream which cut this small gorge may have turned aside and entered the broad drift-filled gorge through one of the channels which were mentioned earlier in this paper as being tributary to this gorge.

*Origin of the rock islands.*—As already shown, there are three rock islands on Map II. In considering the origin of the rock islands, the first question is: Could they have been formed during the normal stream development? A stream abandons its old course and takes a new one when ox-blow lakes are formed; but this happens when the stream is flowing on a flood plain, where the work of cutting across a spur is comparatively easy. In the case which we have to consider the rock is hard enough to offer considerable resistance to stream erosion. Moreover, the shape of the rock island is a serious objection to this theory. If they had been formed by a stream meandering, they should be rounded on the upstream side. Reference to the map will show that all of the rock islands are cut off squarely on the upstream side.

A second way in which rock islands may be formed is by lateral swinging of two streams until they cut through the divide which separates them. If the rock islands had been formed in this way by the uniting of the main stream and a tributary, they should taper to a point on the upstream and downstream sides. None of the rock islands have this form. In the case of the southern rock island, this hypothesis would meet with another objection from the fact that the rock-wall of the old gorge is continuous for one-half mile above the area of Map II.

From what has just been said it seems impossible to attribute the rock islands to normal stream action. Another possible hypothesis is that the rock islands have been formed as a result of glaciation. In this connection, two possibilities arise. Some of these gorges may have been overflow channels of glacial lakes, or the stream may have been forced to cut new channels around glacial deposits which obstructed its former course.

Can any of the gorges be the overflow channel of the glacial lakes? The gorges cannot be the overflow channels of a glacial lake, for there is no place where a lake could form with an outlet at this point. Any lake formed in front of the ice in the

inlet would drain over the divide at Spencer Summit, and the drainage of a small lake in Ten Mile Creek valley would naturally have to pass over the divides, not along the axis of the valley where these channels are located. For this reason, any gorges which would be formed as overflow channels ought to show on the divides, where a careful search has revealed none.

FIG. 5.—Looking down stream. Postglacial gorge of Map No. II on the right. Gorge D on the left.

Could the gorges have been formed interglacially? After glaciation, streams naturally begin to flow along the lowest courses. If the drift deposit is great enough to obscure much of the preglacial topography, the streams may take very different courses from those occupied preglacially; but if the amount of drift-filling is slight, they will naturally follow preglacial drainage lines. There may be partial abandonment of old drainage lines, as in the Genessee River,[1] or the stream may follow

[1] An enumeration of the cases of reversions of drainage which have been described by various writers would be too large an undertaking for the scope of this

approximately its preglacial course. It is possible, then, that these may be interglacial channels, but it would be just as impossible to have them all formed in one interglacial period as to have them all formed during normal stream development.

The hypothesis that some of the gorges were cut because of drift obstructions requires no different conditions from those existing in scores of places near here. Ten Mile Creek has been forced to cut three short postglacial gorges, because of such obstructions. The acceptation of the above hypothesis calls for a greater number of epochs of deglaciation than has heretofore been recognized in this region; but when we consider the great complexity of drift deposits, which has been recognized elsewhere, we do not feel that it is necessarily an objection. This hypothesis has no facts opposed to it, while all the others are open to objections which arise from conditions in the field; therefore we may regard it as established.

*Age of the gorges.*—A considerable lowering of the divide between the Cayuga River and the northward-flowing streams might have produced a rejuvenation of the streams tributary to Cayuga Valley. There is, however, little doubt that the Laurentian streams were stronger than the Susequehanna; consequently such a rejuvenation at the time of the first glacial invasion is improbable. What may have been the exact conditions governing the erosion at the divide during the remainder of the glacial period is, as yet, unknown.

Ten Mile Creek was a small tributary near the source of the preglacial Cayuga River, and would not feel the effect of an uplift until long after the rejuvenation had begun in the lower reaches of the stream. It is also questionable whether the uplift occurred long enough before the glacial period to permit the rejuvenation of the entire Laurentian drainage before its lower reaches were obstructed by ice. Nevertheless, the possibility of such rejuvenation must not be ignored.

paper. Among the best known and most extensive are those of upper Ohio, described by CHAMBERLAIN AND LEVERETT, *American Journal of Science*, Third Series, Vol. XLVII, No. 280, pp. 247–82. For descriptions of local reversions see *Physical Geography of New York* (1902).

While we cannot eliminate the possibility of a preglacial rejuvenation, we can limit the effect in Ten Mile Creek valley. The bottom of the broad valley in Ten Mile Creek is about 720 feet A. T., and there is a shelf in the drift-filled gorge at 620 feet A. T. A differential uplift increasing at the rate of three feet per mile (which would be a fair estimate) to the northeast might cause trenching to 620 feet A. T. without producing a rejuvenation of the streams of the "Elkland-Tioga Folio." To permit erosion to the lowest known point in this gorge would call for an uplift twice as great, while to reach the lowest known depth of any of

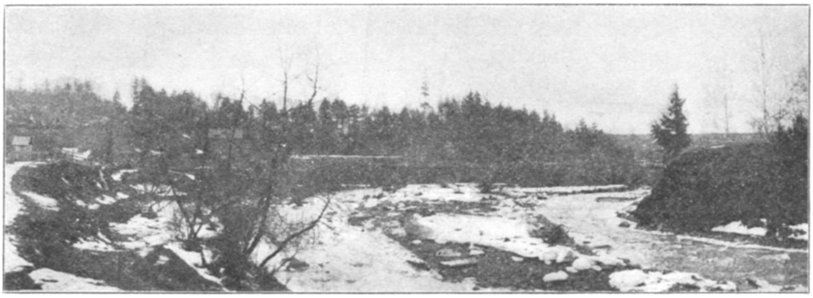


FIG. 6.—A view of the middle ridge looking down stream.

the gorges would require an uplift which would effect the streams south of the divide. Therefore, it seems safe to conclude that the main trenching of the broad valley was interglacial, and that in the case of Ten Mile Creek the preglacial uplift did not cause the stream to cut below 620 feet A. T. There is considerable evidence that the broad valley of Six Mile Creek contains two drift-filled gorges with their bottoms below 540 feet A. T. This fact would seem to indicate at least two periods of deep trenching after the first glacial invasion.

*The length of the deglaciation intervals.*—In considering the length of the intervals of deglaciation, we are confronted by a great many difficulties. One of the most troublesome points is our lack of knowledge of the depth of the various gorges. Another difficulty, which is almost equally troublesome, is the uncertainty as to their chronological order. From the fact that

the buried gorge ($D$) south of the house has its bottom at 910 feet A. T., while all the others have been excavated to a still greater depth, we may conclude that excavation of the gorges to their greatest known depths would require a large amount of erosion since the glacial period. If all the gorges are interglacial, the ice must at one time have retreated far enough to permit gorges to be cut down to, if not below, the present lake level. This would probably require a northward drainage A comparison of the relative widths and depths of the various gorges shown on Map II brings out the fact that the amount of erosion required to excavate the buried gorges was considerably greater than the amount accomplished in postglacial times. This subject is complicated by the fact that the drainage basin of Ten Mile Creek has been reduced in postglacial times; but even making a large allowance for this reduction in drainage area, we may safely say that the shortest interval of deglaciation was probably fully as long as the postglacial time, while the others were considerably longer—in at least one case, several times as long,

*Cause of the gorge-cutting.*—In the formation of the broad valleys the streams must have reached base level. The only thing that could bring about rejuvenation of the streams, resulting in gorge-formation, is an uplift of the land. This uplift must have been of long duration, even though the streams may have found some of their work of degradation, below the old valley floors, accomplished by glacial erosion. The amount of this uplift cannot be determined; but from the fact that the buried gorge of Six Mile Creek has been cleared of drift down to 420 feet A. T., without reaching rock bottom, it follows that the uplift must have been sufficient to permit the stream to cut below that depth. The buried gorge of Butternut Creek, on the west side of the Inlet Valley, is over 250 feet deep; hence the amount of uplift must have been at least 250 feet. Since Butternut Creek is at present flowing 250 feet below the old valley floor, we may also assume that the postglacial altitude is probably fully 250 feet greater than the altitude when the broad valleys were formed.

*Summary.*—Briefly summarized, this paper is intended to show the existence of a series of complex gorges which are considered interglacial. The minimum number of epochs of deglaciation is two; the maximum number, four. The amount of ice recession was probably sufficient, in at least one case, to permit a northward drainage. The length of the epochs of deglaciation can be only roughly estimated, but the shortest was probably as long as postglacial time, and the others were doubtless much longer. The main trenching of the broad valleys was interglacial, and the minimum amount of interglacial elevation is placed at 250 feet. The land is probably more than 250 feet higher at the present time that it was during the time of the formation of the broad valleys of Cayuga Lake region.

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